Quarterly Report—Public Page

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Prepared for: United States Department of Transportation
Pipeline and Hazardous Materials Safety Administration
Office of Pipeline Safety

Project Title: "Understanding Magnetic Flux Leakage (MFL) Signals from Mechanical Damage in Pipelines"

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For quarterly period ending: June 30, 2011

Public Page Section- This section contains information on the technical status of the Project and the milestones completed during the quarter. Information will be information that PHMSA may release to the public in whole or in part at any time. The information must not contain proprietary data or confidential business information. The Team Project Manager must provide a point of contact for coordination, preparation, and distribution of any press releases.

Technical Results and Conclusions

TASK 4: Administration and Reporting

The team is awaiting comments from DOT PHMSA and PRCI on the Phase III Draft Final Report and will address any comments.

Task 15.2: Gouged Dent Modeling

The team extended their prior work on gouge+dent models for axial and radial field maps to include the same defect in the circumferential direction. Queen's produced MFL contour maps of all three components and will include the results in the final report.

Tasks 16.1 and 16.2: Detector Trajectory Modeling

The team simulated the effect of detector liftoff on MFL signal components by modeling three different detector trajectories with varying degrees of liftoff at the underside of defects created in Tasks 14 and 15. Three such trajectories used for plain circular dents are shown in Figure 1. These trajectories were estimated using a spring model with three different spring constants of 30, 50 and 100 N/m and a constant detector speed of 4 m/s with detector moving in the positive x-direction. The dent depth is 12 mm and dent radius is 28 mm. The inner wall axial MFL contour maps are shown in Figures 2a through 2d, and the corresponding radial maps are shown in Figures 3a through 3d. Both the axial and radial maps indicate an asymmetry caused by detector liftoff. The signal near the trailing end (right half of the map) is weaker than the signal near the leading end. The effect is more pronounced on the radial signal where the outer peak is almost completely eliminated for the case of Trajectory-C. Thus, the greater detector liftoffs may produce MFL field maps where the outer peak near the trailing end may be absent.

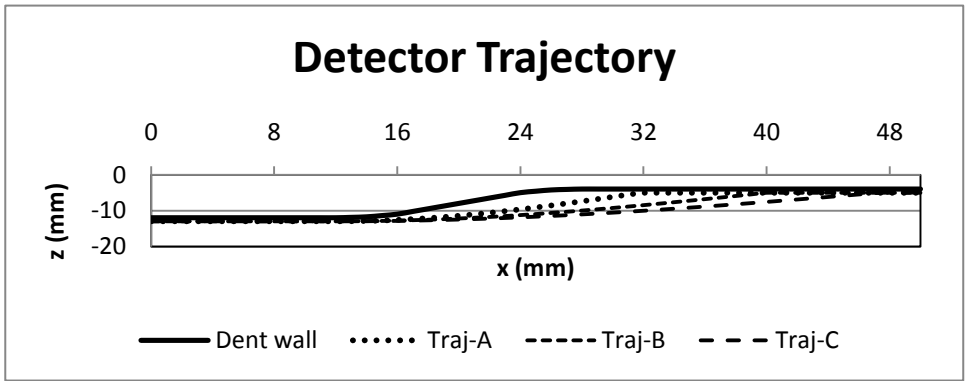

Figure 1: *Cross-section of a half circular dent along with three different detector liftoff trajectories (A, B and C) on the underside of the dent.*

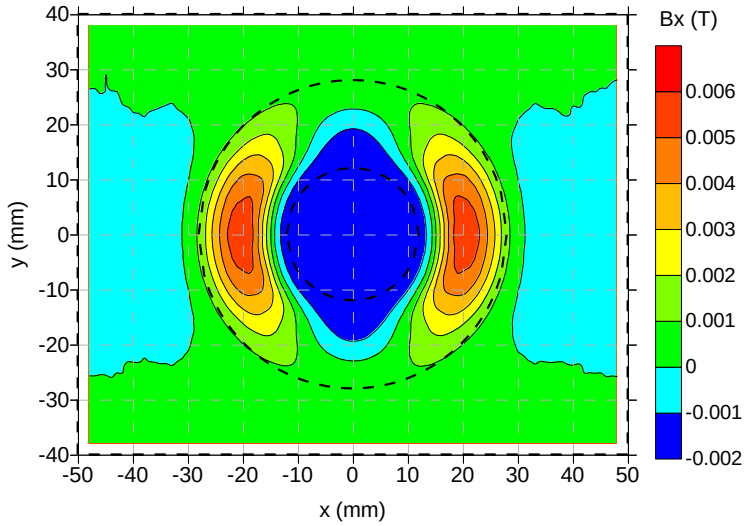

Figure 2a: *MFL axial map of circular dent obtained at inner dent wall at a uniform lift of 1 mm.*

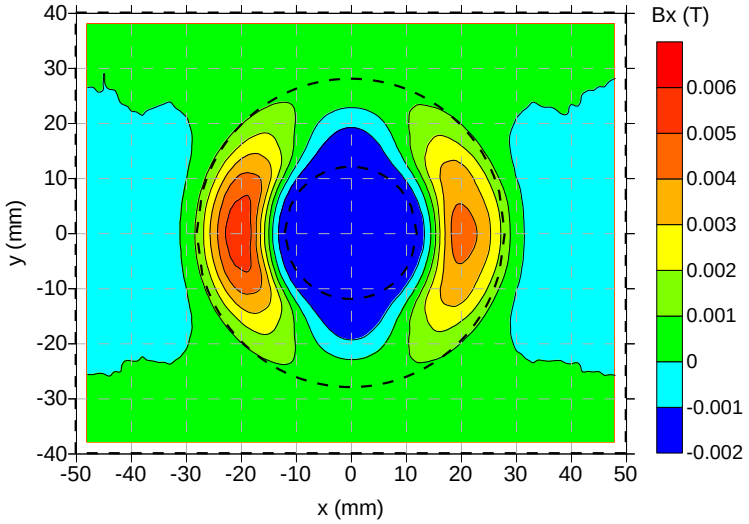

Figure 2b: *MFL axial map of circular dent obtained at Trajectory-A shown in Figure 1.*

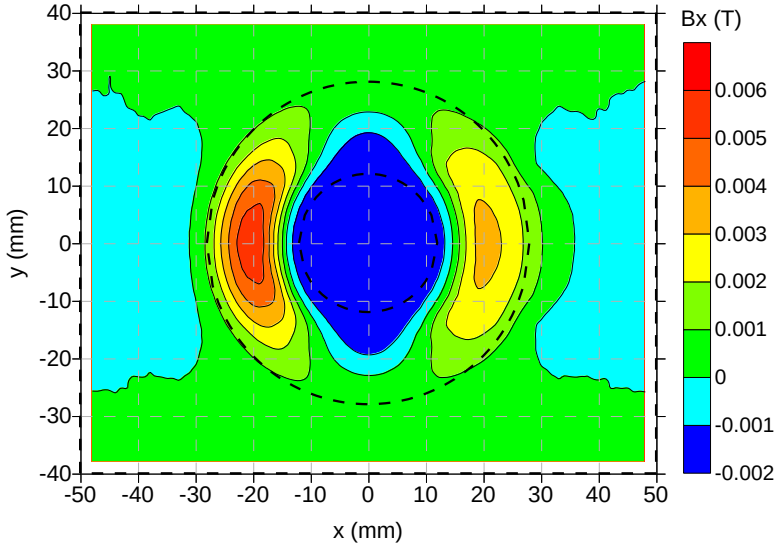

Figure 2c: *MFL axial map of circular dent obtained at Trajectory-B shown in Figure 1.*

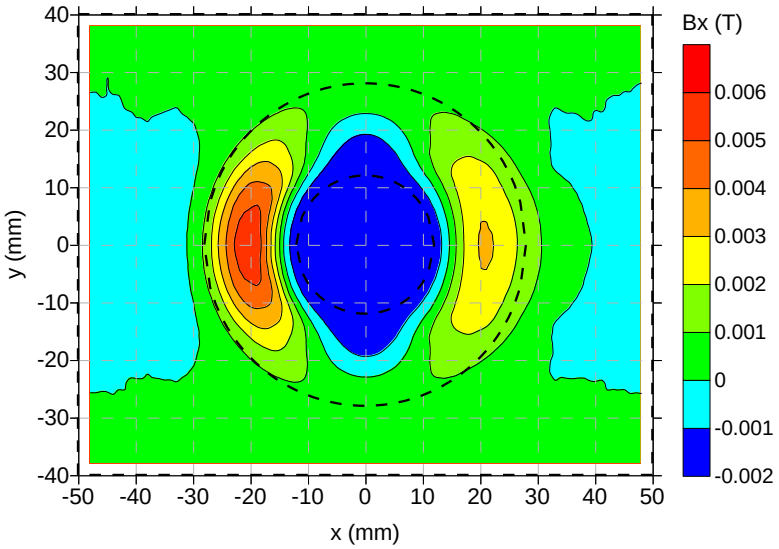

Figure 2d: *MFL axial map of circular dent obtained at Trajectory-C shown in Figure 1.*

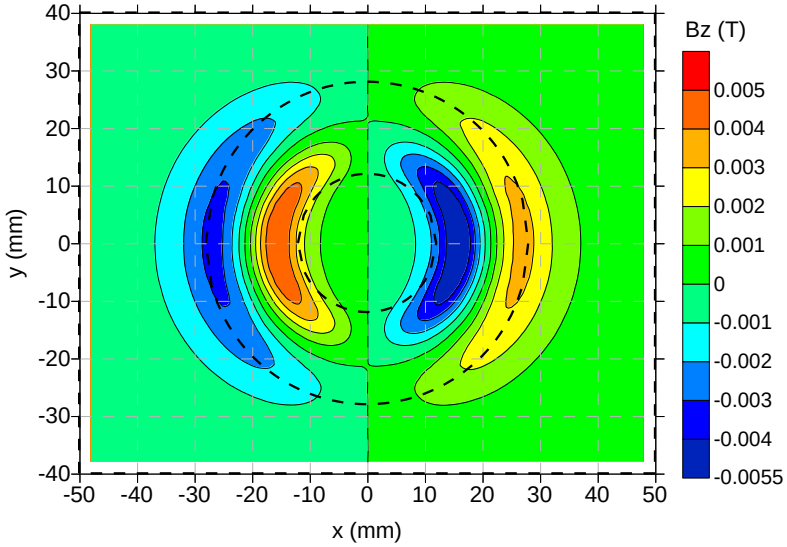

Figure 3a: *MFL radial map of cirular dent obtained at inner dent wall at a uniform lift of 1 mm.*

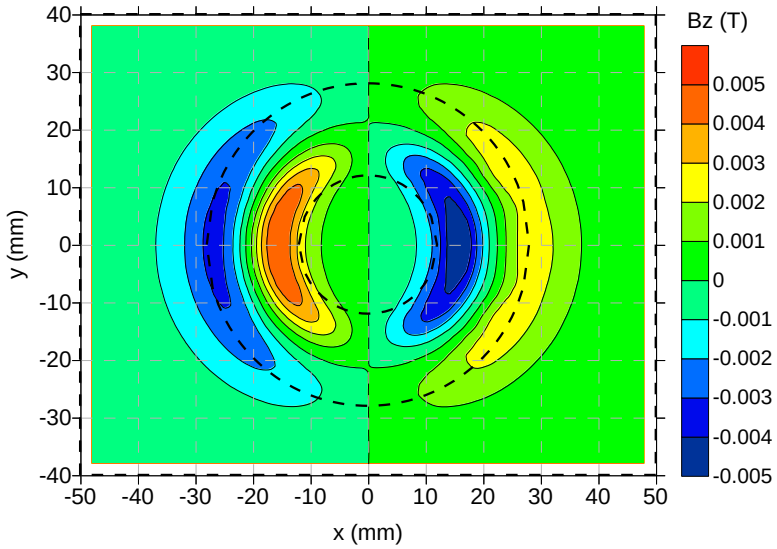

Figure 3b: *MFL radial map of circular dent obtained at Trajectory-A shown in Figure 1.*

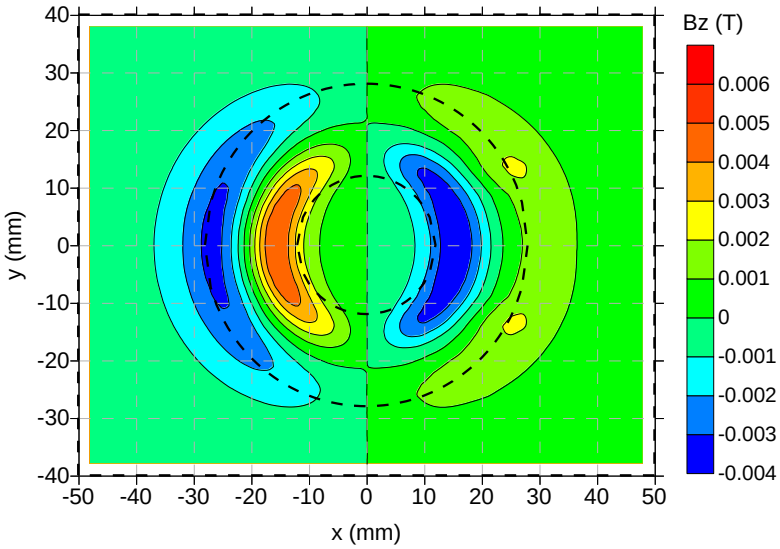

Figure 3c: *MFL radial map of circular dent obtained at Trajectory-B shown in Figure 1.*

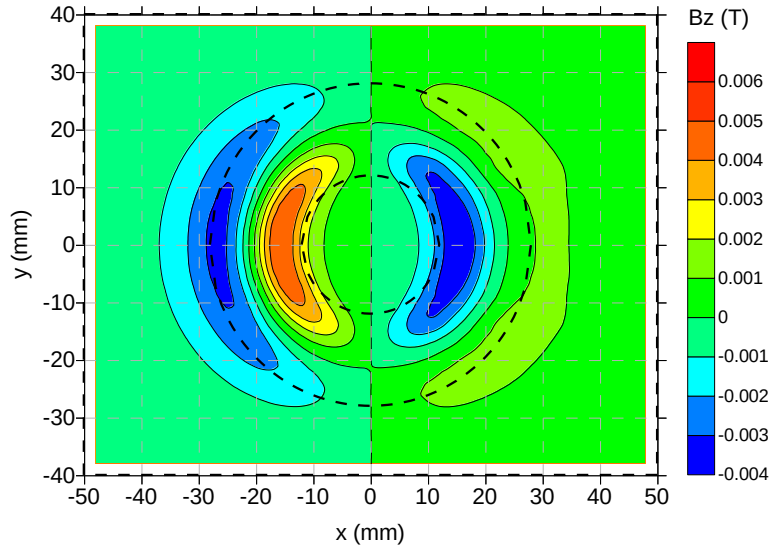

Figure 3d: *MFL radial map of circular dent obtained at Trajectory-C shown in Figure 1.*

Task 17: Magnet Pole Piece Liftoff Modeling

The MFL axial and radial maps from a circular dent with 50% discontinuity fraction and no liftoff are shown in Figure 4. As revealed, the discontinuity fraction affects both the nature and strength of the axial signal. Although the nature of the radial signal remains practically unchanged, its strength decreases by about 20%. This is apparently due to liftoff of one of the pole pieces and more flux being diverted around the defect region rather than passing directly through the defect from one pole piece to the other.

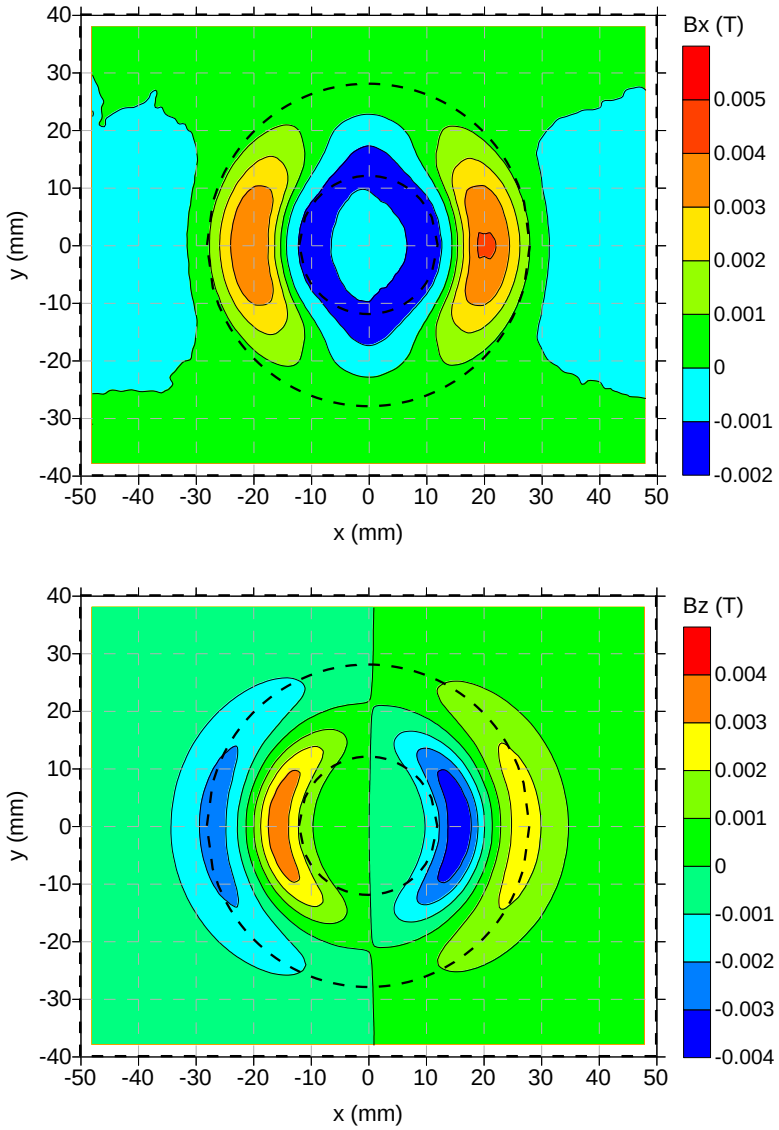

Figure 4: *Modeled MFL axial (top) and radial (bottom) maps of circular dent associated with a discontinuity fraction of 50% with no liftoff.*

Task 18: Experimental Verification Measurements

For experimental verification of modeled results presented in Tasks 16.1 and 16.2 above, the team used samples from the previous and concurrent projects and applied Play-Doh on one side of the defect to mimic the detector liftoff trajectories used in the model. The experimental MFL axial and radial field maps for a typical liftoff trajectory (close to Trajectory-B/C of the model) are shown in Figure 5. The signal on the trailing end (right hand side of the map) is weaker than the signal on the leading end, which agrees with the model predictions. As found in the modeled signal, the trailing end outer radial peak is almost completely missing in the experimental field map as well.

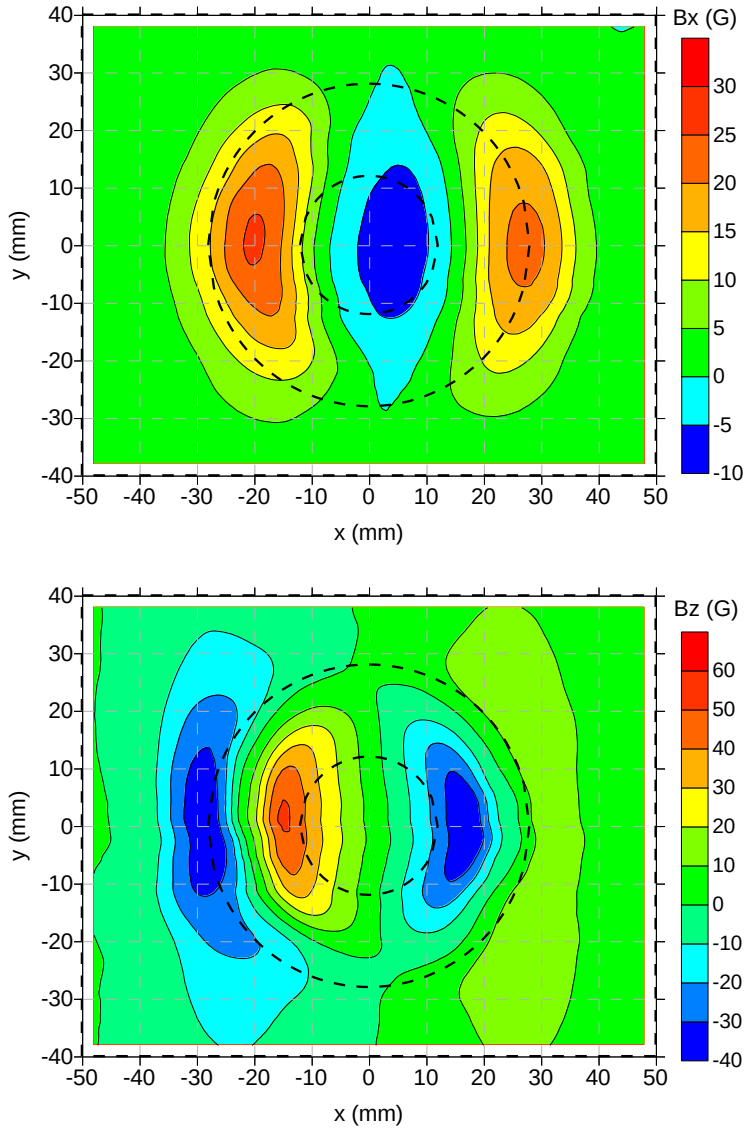

Figure 5: *Experimental MFL axial (top) and radial (bottom) maps of circular dent obtained at Trajectory-C shown in Figure 1.*

Task 19: Data Analysis

The team is conducting data analysis on multiple levels, including a qualitative contour plot comparison between the overall MFL signals for 'ideal' and 'liftoff' cases; and (a quantitative analysis to determine the percent loss in signal as a function of detector and pole piece liftoff. This is an ongoing Task and will be continued in the next quarter when more data from other defects become available.

Issues, Problems or Challenges

Due to contracting issues, the modification with DOT PHMSA was not executed until January 2011, although the project schedule began in September 2010. The team has already made up significant time and believes it can meet the overall project schedule by accelerating the work done in the next few quarters.

Plans for Future Technical Activity

The following work is planned for the next Quarter:

- Model the effect of discontinuity fraction for dent+gouge defects with and without detector liftoff.
- Experimental verification of MFL signals from samples of previous and concurrent measurements.
- Qualitative and quantitative analysis of the modeling results.
- Respond to comments on the Phase III Draft Final Report.